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Impact of insecticides on spiralling whitefly, *Aleurodicus dispersus* (Hemiptera: Aleyrodidae) and its natural enemy complex in cassava under open field conditions

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ABSTRACT

Although insecticides can be used to control pests on cassava (*Manihot esculenta* Crantz.) they could have detrimental effects on natural enemies. Nine important insecticides, thiamethoxam, imidacloprid, buprofezin, acetamiprid, spiromesifen, triazophos, acephate, thiodicarb and thiacloprid, were selected to test their efficacy against spiralling whitefly, *Aleurodicus dispersus* (Hemiptera: Aleyrodidae) to clarify selectivity of these insecticides on its natural enemies. All insecticides caused substantial reduction in spiralling whitefly populations on cassava during two seasons. Acephate and triazophos were effective in controlling the spiralling whitefly population (>90% reduction in both seasons) on cassava and recorded higher tuber yield than other insecticidal treatments during both the seasons. All insecticides significantly reduced the emergence of parasitoids (*Encarsia guadeloupae* Viggiani and *Encarsia meritoria* Gahan) and percent parasitism (<1%) when compared with the control. However, buprofezin was relatively less toxic to *Cybocephalus* spp. and *Mallada astur* (Banks) than other insecticides. To summarize, buprofezin can be included in Integrated Pest Management (IPM) programs since it was comparatively effective in controlling of *A. dispersus* (>75% reduction in both seasons) and relatively less toxic to *Cybocephalus* spp. and *M. astur* which are the major predators of spiralling whitefly in cassava.

1. Introduction

Cassava (*Manihot esculenta* Crantz.) is the sixth most important crop worldwide and it constitutes the staple food for over 700 million people (Njoku et al., 2010). It has the capacity as an agricultural crop to produce large amounts of food calories per unit area and can adapt to erratic climatic conditions (Magoon, 1967; Adeniji et al., 2011). Cassava is subjected to attack by many pests. Among its insect pests, spiralling whitefly, *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae), can cause 50–65% of losses in cassava per year (Geetha, 2000; Boopathi et al., 2014a). The spiralling whitefly is a polyphagous pest with an extensive host range (Srinivasa, 2000). It has six life stages (Banjo and Banjo, 2003). *Aleurodicus dispersus* feeds on the underside of the leaves; leaf structure appears to influence feeding preference (Wen et al., 1994). Direct feeding damage is caused by piercing and sucking of sap from foliage by immature and adult stages. Feeding by large populations causes premature leaf drop and produces large amounts of honeydew which serve as a substrate for sooty mould growth (Akinlosotu et al., 1993; Boopathi et al., 2013). Sooty mould decreases photosynthetic activity and vigour and often causes tissue deformations (Kumashiro et al., 1983). Currently, control measures rely heavily on the use of insecticides belongs to organophosphates, carbamates and synthetic pyrethroids.

New insecticides have good potential for use in Integrated Pest Management (IPM) programs as they are more selective with toxicity to target pests even at lower dose and often not as persistent as conventional insecticides. However, indiscriminate use of insecticides results in resistance development in pest populations (Georghiou and Lagunes, 1991), and can be detrimental to the environment. The advent of new insecticides has prompted renewed interest in examining and improving the role of natural

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enemies in cassava pest management. Many species of parasitoids, such as *Encarsia guadeloupae* Viggiani and *Encarsia meritoria* Gahan (Aphelinidae: Hymenoptera) and predators, *Cybocephalus* spp. (Cybocephalidae: Coleoptera), *Scymnus coccivora* Aiyar (Coccinellidae: Coleoptera), and *Mallada astur* (Banks) (Chrysopidae: Neuroptera), naturally inhabit cassava fields and they are generally thought to play an important role in maintaining the population of potential cassava pests [e.g., *A. dispersus* and *Bemisia tabaci* (Gennadius)] at harmless densities. However, synthetic insecticides are often harmful to natural enemies and detrimental to their conservation. Under IPM programs, coordination between pesticide use and biological control is essential. Therefore, it is necessary to search for alternative and effective insecticides against spiralling whitefly. Results from tests on the bioefficacy of some newer insecticides are lacking along with information on their safety to natural enemies. The present study was undertaken to evaluate the efficacy of some newer insecticides in controlling spiralling whitefly and to determine their selectivity on its parasitoids (*E. guadeloupae* and *E. meritoria*) and predators (*Cybocephalus* spp., *S. coccivora*, and *M. astur*).

2. Materials and methods

2.1. Insecticides

Nine insecticides, thiamethoxam, imidacloprid, buprofezin, acetamiprid, spiromesifen, triazophos, acephate, thiodicarb and thiacloprid (Table 1), were selected to test relative efficacy against spiralling whitefly and to determine their selectivity to common natural enemies.

2.2. Field experiments

This study was conducted at an experimental farm located in Kinathukadavu, Coimbatore, Tamil Nadu, India at 307 m above mean sea level at 10°49′10.12″N latitude and 77°52.66′E longitude, and has a tropical climate. Field experiments were conducted in cassava for the seasons, 2011–2012 (season 1) and 2012–2013 (season 2). The experimental field was tilled three times with a power tiller, pulverized, and prepared and divided into 30 plots each 100 m^2 in size. A 100-cm wide space was left between neighboring plots. Rooted sets (stems having two buds) of cassava (cv. Mulluvadi–1) were planted at a spacing of 90 × 90 cm. Treatments were applied to 3 replicates arranged in a Randomized Complete Block Design (RCBD). Weeding, fertilization, and other cultural operations were made according to established production guidelines (TNAU, 2012). Furrow irrigation (approximately 700–800 L/plot) was applied every 2–3 weeks in the absence of rain. The first spray was made at the vegetative stage of cassava. The second spray covered new leaves and shoots, and increased populations in newly emerged nymphs and adults of spiralling whitefly. The second spray was made 15 days after the first application. Both sprays were made on the same plants. An untreated check was maintained during the study. Spray was with a hand-held, single-nozzle and atomizing (air-assist) sprayer, pneumatic knapsack sprayer (manufacturer: ASPEE India, Mumbai, Maharashtra, India and model: SRP/50). The spray nozzle was carried near ground level and directed at a right angle to the row. Each row was treated twice, once on each side of the row. Spray volume was 16 L/100 m^2. Average daily temperatures in the open field during two seasons ranged between 20.8 and 32.3 °C with relative humidity ranging between 72 and 85.0%; there was no rainfall during the period of observation making conditions favorable for pest outbreak development.

2.3. Effect of insecticides on spiralling whitefly population on cassava

Densities of nymphs and adults of spiralling whitefly were estimated 24 h before each insecticide application, and post-treatment observations were at 1, 4, 7, 10, and 15 days after each spray (DAS). Densities of nymphs and adults were estimated by counting individuals, on the under and upper sides of 3 leaves from the top, middle, and bottom (Naranjo and Flint, 1994, 1995). Fifteen leaf samples were randomly examined for nymph and adult stages in each plot on each sample date. Yield was recorded for the various treatments (all the plots) and expressed in $t \cdot ha^{-1}$.

2.4. Effect of insecticides on parasitoids population on cassava

The densities of immature aphelinid parasitoids (*E. guadeloupae* and *E. meritoria*) attacking spiralling whitefly were estimated by taking 30 cassava leaf samples from 10 plants (3 leaves per plant). The leaves selected for the study was taken from the 7th main stem node from the terminal. Samples were collected 24 h before each insecticide spray, and post-treatment observations were made at 1, 4, 7, 10 and 15 DAS. In the laboratory, *E. guadeloupae* and *E. meritoria* which emerged from 4th instar nymphs and pupae of spiralling whitefly were counted. Parasitoid and spiralling whitefly exuviae were not counted. Displacement of the host's mycetomes was used to decide the presence of young parasitoid larvae, but in these cases the parasitoid species could not be distinguished. We calculated an index of parasitism based on the proportion of 4th instar nymphs of spiralling whitefly parasitized by both species combined. A subsample of leaves (n = 20) from each plot was used to determine species composition of emerged adults and to measure treatment effects on parasitoid emergence (immature survival). Parasitized hosts were held in a ventilated box at 28 ± 1 °C with 80 ± 5% RH and 14 L:10D photoperiod for 2 weeks.

Table 1
Insecticides used in evaluations of their efficacy against *Aleurodicus dispersus* and safety to natural enemies on cassava.

Brand name	Insecticide	Class	Application rate (g or mL·ha^{-1} a.i.)
Actara	Thiamethoxam 5% WG	Neonicotinoid	25.0
Confidor	Imidacloprid 200 SL	Neonicotinoid	25.0
Applaud	Buprofezin 25% SC	Insect growth regulator (IGR)	250.0
Pride	Acetamiprid 20% SP	Neonicotinoid	40.0
Oberon	Spiromesifen 240 SC (22.9%)	Lipid Biosysthesis inhibitor (LBI)	120.0
Hostathion	Triazophos 40% EC	Organophosphate	500.0
Asataf	Acephate 75% SP	Organophosphate	750.0
Larvin	Thiodicarb 75% WP	Carbamate	750.0
Alando	Thiacloprid 21.7% SC	Neonicotinoid	144.0